8 NUTRIENTS

This section presents water quality results related to nutrient and dissolved oxygen concentrations from the 1995-1997 Maryland Biological Stream Survey (MBSS, or the Survey). Levels of nitrate-nitrogen (NO_3-N) and dissolved oxygen (DO) are examined for streams in each of the basins sampled in the Survey. To assess the comparability of the spatially diverse MBSS data with a less extensive but longer-term data set, results are compared with the nutrient data obtained from DNR's CORE/Trend monitoring stations located throughout the State.

8.1 BACKGROUND INFORMATION ON NUTRIENTS

Nutrients such as nitrogen are important for life in all aquatic systems. In the absence of human influence, streams contain a background level of nitrogen that is essential to the survival of the aquatic plants and animals in that system. However, during the last several hundred years, the amount of nitrogen in many stream systems has increased, as a result of anthropogenic influences such as agricultural runoff, wastewater discharge, and urban/suburban nonpoint sources.

Elevated nitrogen concentrations are one contributor to nutrient enrichment in aquatic systems. Excessive nitrogen loading may lead to the eutrophication of the water body, particularly in downstream estuaries. Eutrophication often decreases the level of dissolved oxygen available to aquatic organisms. Prolonged exposure to low dissolved oxygen values can suffocate adult fish or lead to reduced recruitment. Increased nutrient loads are also thought to be harmful to humans by causing toxic algal blooms and contributing to outbreaks of toxic organisms such as *Pfiesteria piscicida.*

In Maryland, concern for nutrient loadings to the Chesapeake Bay has drawn attention to the amounts of materials transported from throughout the watershed by stream tributaries. In the Chesapeake Bay watershed, the largest source of nitrogen is from agriculture (estimated as 39% of total nitrogen). Other contributors include point sources (23%), runoff from developed areas (9%) and forests (18%), and direct atmospheric deposition to the Bay surface (11%). The total contribution of atmospheric deposition is higher (27%), including amounts deposited to the watershed and subsequently entering the Bay as runoff (Chesapeake Bay Program 1995). Atmospheric deposition is therefore recognized as a significant contributor of nitrogen to the Bay, including deposition reaching the watershed from power plants and other distant sources (Dennis 1996).

The Survey provides a large dataset that can be used to assess nutrient concentrations under spring baseflow conditions. Although a full understanding of nutrient loadings also requires data collected over time (i.e., taken over multiple years and seasons), the Survey's water chemistry results provide extensive spatial coverage (with nearly 1,000 sites sampled) that enables nitrogen concentrations to be compared among basins statewide. Maryland's CORE/Trend monitoring program provides information regarding long-term water chemistry conditions, as described briefly below.

The Survey measures concentrations of NO_3-N, one of the most common forms of nitrogen found in aquatic systems. For the analysis of MBSS data, concentrations were broken down into the following categories: NO_3-N > 7 mg/l (the most highly elevated concentrations observed), > 3.0 mg/l (moderately elevated), >1.0 mg/l (slightly elevated, considered indicative of anthropogenic influence), 0.01-1.0 mg/l, and <0.01 mg/l. The mean instream concentration of NO_3-N was examined statewide and for each individual basin. Dissolved oxygen concentrations, which may be affected by NO_3-N concentrations, were broken down into the following categories: DO < 3 ppm, 3-5 ppm, and > 5 ppm.

8.2 RESULTS OF NUTRIENT ASSESSMENT

Statewide, the majority of stream miles (59%) had NO_3-N concentrations greater than 1.0 mg/l. An estimated 41% of stream miles had NO_3-N concentrations between 0.1 mg/l and 1.0 mg/l, and only 0.4% had concentrations that were less than 0.1 mg/l. Only three basins had any stream miles (< 5%) with less than 0.1 mg/l of NO_3-N: the Upper Potomac, the Lower Potomac, and the West Chesapeake. An estimated 29% of stream miles had a NO_3-N concentration greater than 3.0 mg/l and an estimated 5% of stream miles had a NO_3-N concentration greater than 7.0 mg/l. Areas where the concentration is greater than 7.0 mg/l are places where NO_3-N may be especially detrimental to stream quality. These areas occurred in seven of the basins sampled: Upper Potomac, Middle Potomac, Lower Potomac, Patuxent, Patapsco (1995 and 1997 sampling), Susquehanna, Elk, Chester, Choptank (1996 and 1997 sample years), and Nanticoke/Wicomico basins. Figure 8-1 shows the percentage of stream miles by basin where NO_3-N concentrations were greater than 1.0 mg/l and that which is greater than 7.0 mg/l.

The mean statewide NO_3-N concentration was 2.45 mg/l. First-order streams had a slightly higher mean NO_3-N concentration (2.56 mg/l) than either second (2.21) or third-order (2.15) streams. Eight basins had average NO_3-N concentrations greater than the statewide average: the Middle Potomac, Patapsco (1995 and 1996 sampling), Gunpowder, Susquehanna, Elk, Chester, Choptank (1996 and 1997 sampling), and Nanticoke/Wicomico basins. For the most part, these are the same basins that had sites with NO_3-N concentrations greater than 7.0 mg/l. The distribution of the mean NO_3-N concentration by basin is shown in Figure 8-2.

Organisms unable to tolerate polluted conditions may be reduced or eliminated in streams with elevated nutrient concentrations. For example, numbers of benthic Ephemeroptera, Plecoptera, and Trichoptera (EPT), taxa generally sensitive to degradation, were diminished in streams with higher NO_3-N concentrations (Figure 8-3).

The Hilsenhoff Biotic Index is a useful measure of the intolerance of benthic macroinvertebrates to organic pollution (Hilsenhoff 1977, 1987, 1988; Klemm et al. 1990; Plafkin et al. 1989). It is expected that the Index would be high (indicating greater prevalence of tolerant taxa) where instream concentrations of NO_3-N are high. Statewide, the Hilsenhoff Biotic Index and NO_3-N concentration were significantly related (linear regression, $p<0.0001$, $r^2=0.03$; Figure 8-4), but there was a great deal of variation when all sample sites were pooled.

In some aquatic systems, low dissolved oxygen levels may result from nitrogen inputs. Statewide, the majority of stream miles contained dissolved oxygen concentrations that were greater than 5.0 ppm (94%), a level generally considered healthy for aquatic life. An estimated 3% of stream miles had dissolved oxygen concentrations that fell between 3.0 ppm and 5.0 ppm, while 3% had concentrations less than 3.0 ppm. Seven basins had stream miles with a dissolved oxygen concentration less than 3.0 ppm: the Upper Potomac, Lower Potomac, Patuxent, West Chesapeake, Patapsco (1996 sampling), Chester, and Pocomoke basins (Figure 8-5). This result suggests that high NO_3-N levels are ameliorated by reaeration and other factors. Seasonal monitoring of streams suspected to have low DO problems and examination of watershed factors would help to diagnose situations where the problem is persistent and can be linked to anthropogenic causes.

8.3 COMPARISON WITH CORE/TREND MONITORING DATA

Maryland DNR's CORE/Trend program, begun in 1974, is part of the State of Maryland's long-term ambient monitoring of stream water quality. Surface water samples are collected monthly at 55 stations located throughout the State and analyzed for a variety of physiochemical parameters. In addition, benthic macroinvertebrates are sampled annually at 27 of these stations. Stations from the CORE/Trend program are located in 11 of the 17 basins in the State: the Youghiogheny, North Branch Potomac, Upper Potomac, Middle Potomac, Potomac Washington Metro, Patuxent, Patapsco, Gunpowder, Susquehanna, Chester, and Choptank.

To compare CORE/Trend data with MBSS results, NO_3-N values from the CORE/Trend stations were examined for April and May of 1995, 1996, and 1997. For each station, the mean for these two months was calculated by year (Figure 8-6). These data, averaged across the three years, were compared to the mean NO_3-N results from the MBSS (Figure 8-7).

Overall, the statewide average NO_3-N concentration from the CORE/Trend data was 1.82 mg/l, while the average statewide NO_3-N concentration from the MBSS data was 2.45 mg/l. Average NO_3-N concentrations in the Youghiogheny and the North Branch Potomac basins were both consistently low, showing very little difference between monitoring programs. In the Upper Potomac and Patuxent basins, the average NO_3-N concentration was higher at the CORE/Trend stations than at the MBSS sites. In the remaining basins that were sampled in both programs, the NO_3-N concentration was higher at the MBSS sample sites than at the CORE/Trend stations. The greatest difference was in the Choptank basin where MBSS data sets had an average NO_3-N concentration of 4.13 mg/l, while the CORE/Trend data had an average concentration of 1.32 mg/l. Differences in values within individual basins are, in part, explained by differences in sample site locations. MBSS sites do not necessarily occur in the same parts of the basin sampled by the CORE/Trend program, and some CORE/Trend sites may be influenced by conditions outside of areas sampled by MBSS. For example, CORE/Trend sites on the mainstem Potomac River may be affected by farming activity in West Virginia or Virginia.

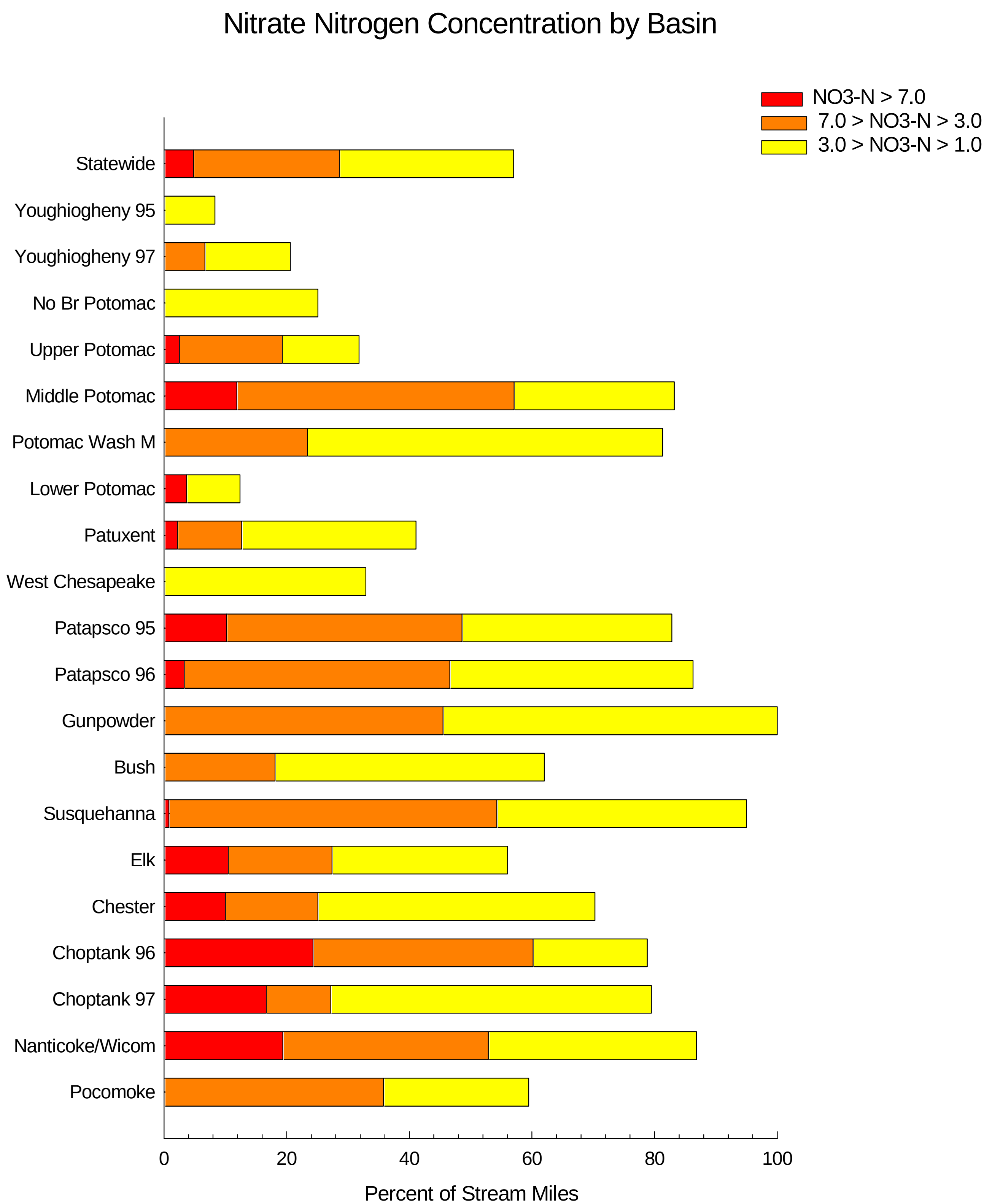

Figure 8-1. Nitrate nitrogen (NO_3-N) concentration (mg/l) statewide and for basins sampled in the 1995-1997 MBSS. Categories shown are: NO_3-N > 7.0 mg/l, 7.0 mg/l > NO_3-N > 3.0 mg/l and 3.0 mg/l > NO_3-N > 1.0 mg/l.

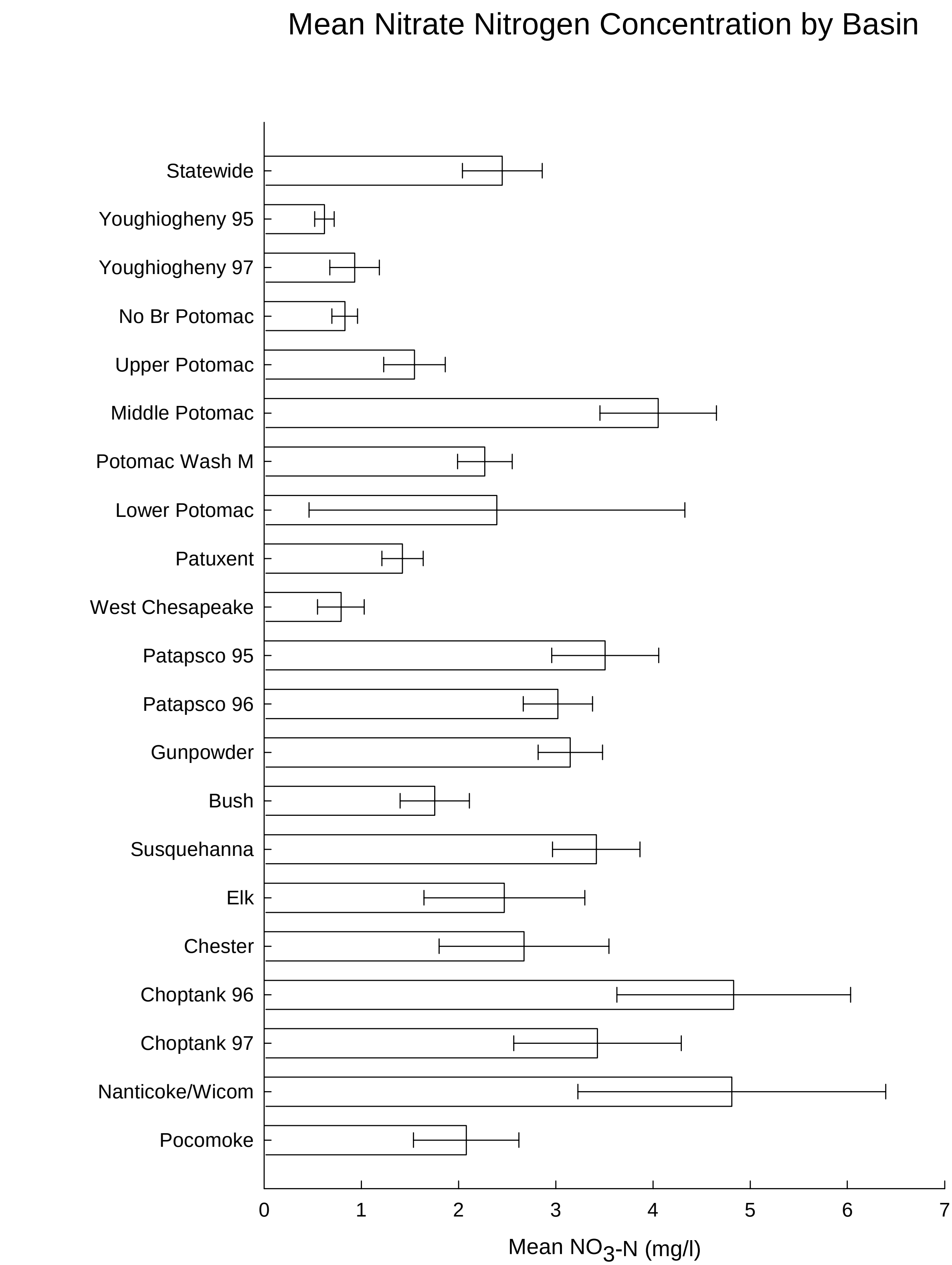

Figure 8-2. Mean nitrate nitrogen (NO_3-N) concentration (mg/l) statewide and for basins sampled in the 1995-1997 MBSS. Error bars indicate ±1 standard error.

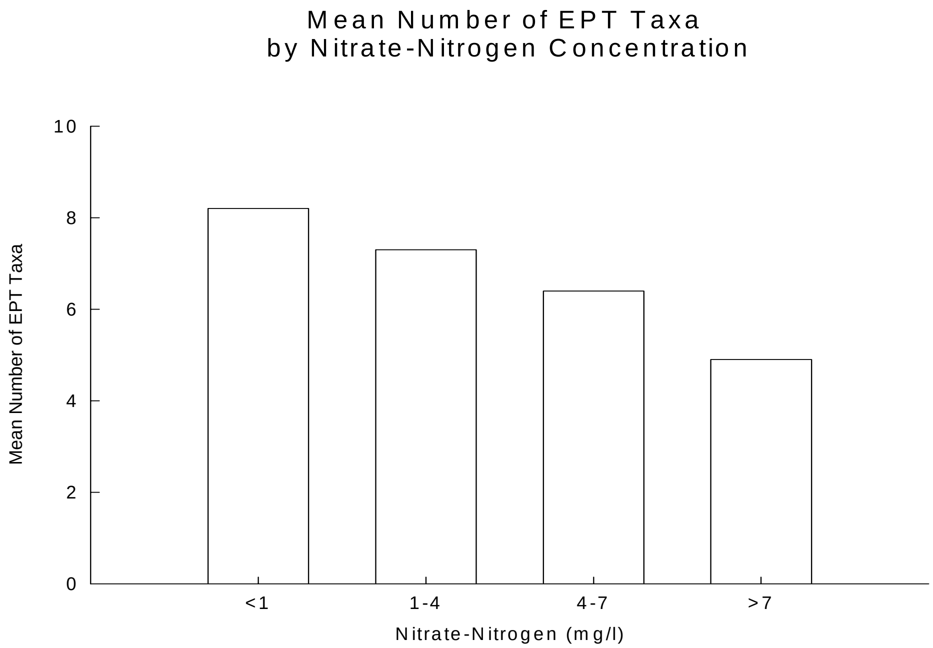

Figure 8-3. Mean number of benthic Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa declined with higher nitrate nitrogen concentration at 1995-1997 MBSS sites

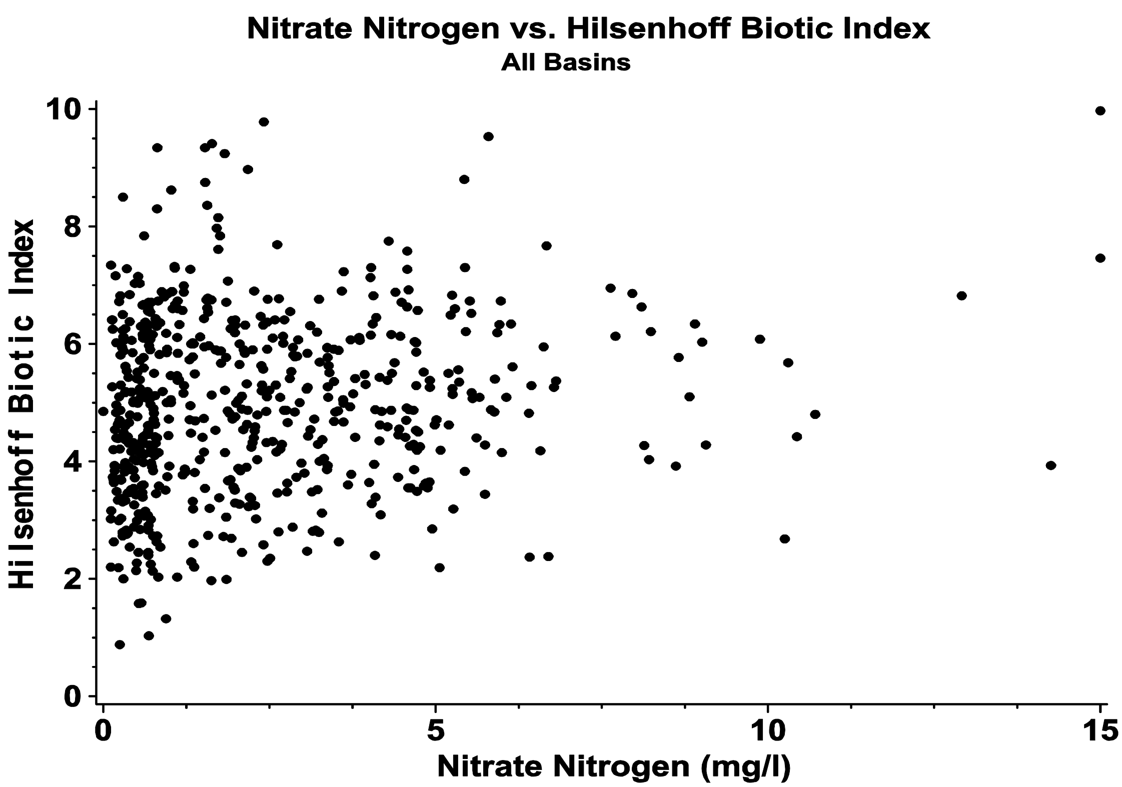

Figure 8-4. Relationship between nitrate nitrogen (NO_3-N) concentration (mg/l) and the Hilsenhoff Biotic Index for the 1995-1997 MBSS ($p<0.0001$, $r^2=0.03$)

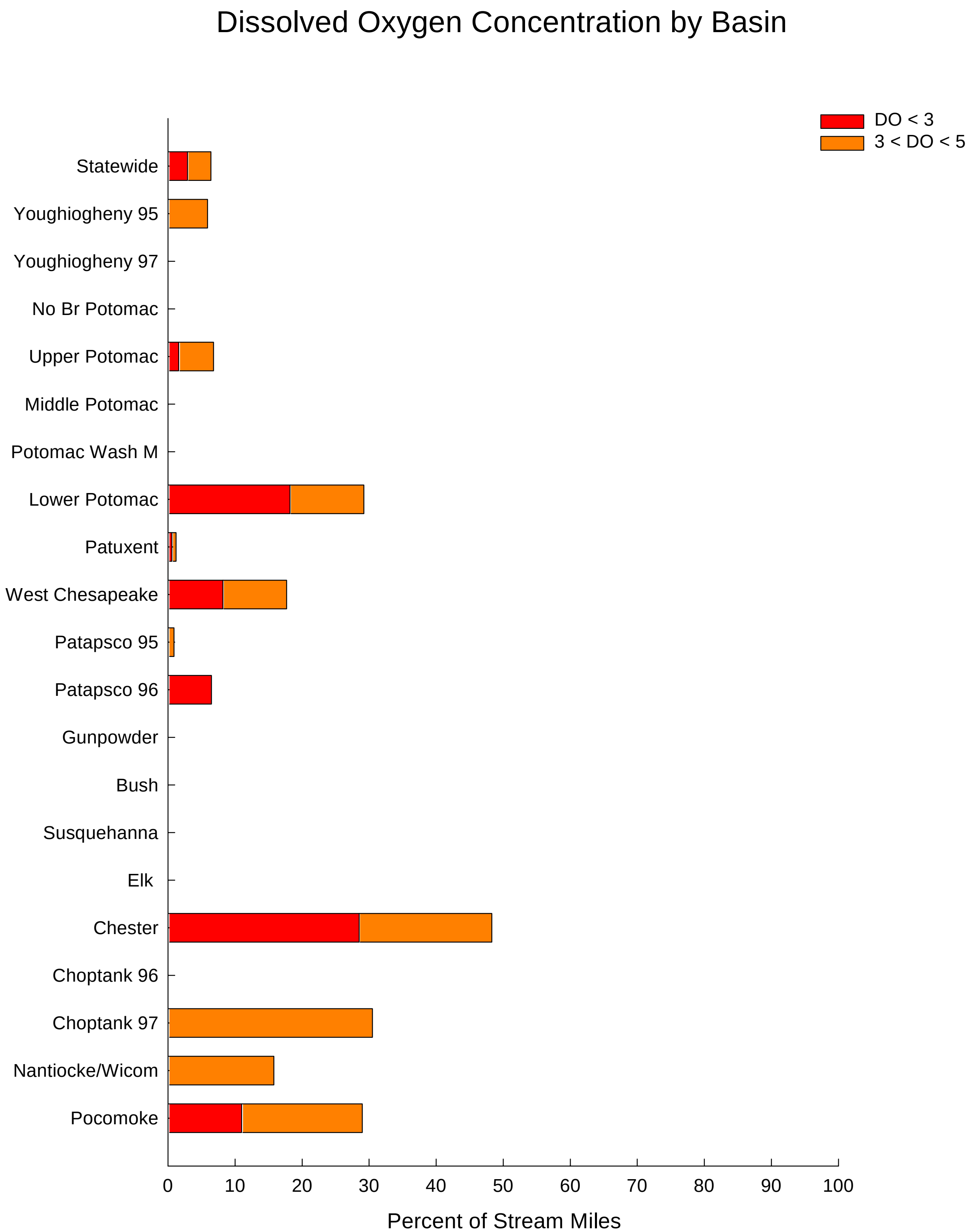

Figure 8-5. Dissolved oxygen (DO) concentration (ppm) statewide and for basins sampled in the 1995-1997 MBSS. Categories shown are: DO < 3 ppm and 3 ppm < DO < 5 ppm.

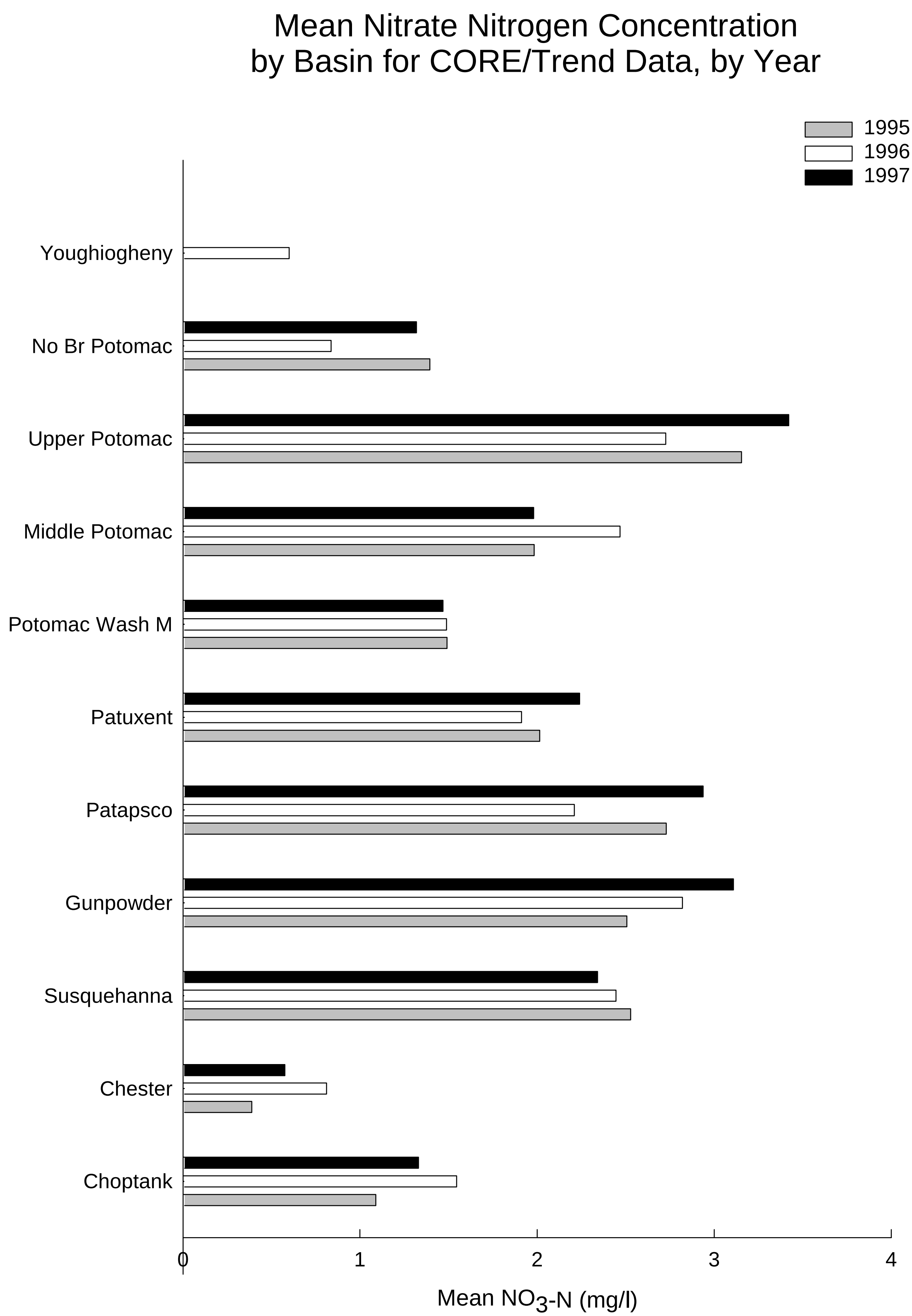

Figure 8-6. Mean nitrate nitrogen (NO_3-N) concentration (mg/l) for CORE/Trend stations sampled in April and May of 1995, 1996, and 1997

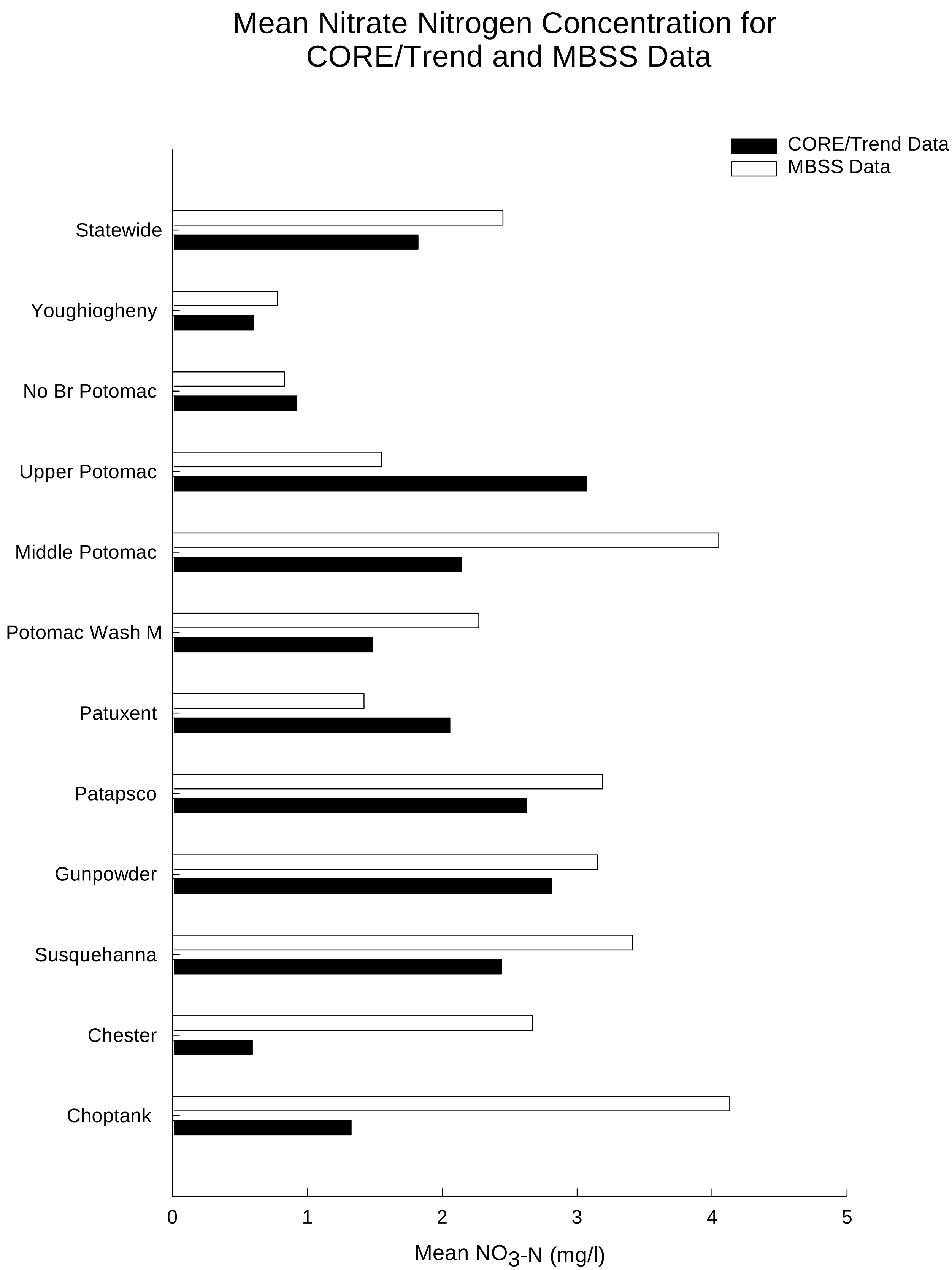

Figure 8-7. Mean nitrate nitrogen (NO_3-N) concentration (mg/l) for CORE/Trend stations sampled in April and May of 1995-1997 and for MBSS sites sampled during the spring index period of 1995-1997.

To examine whether data from the two programs tend to rank basins in a similar order, a Spearman rank correlation of NO_3-N concentrations was conducted. Three basins were excluded from the analysis due to obvious differences in areas covered by sampled locations. The CORE/Trend station in the Susquehanna basin is located in the mainstem river and therefore is likely to be influenced by Pennsylvania streams. Similarly, CORE/Trend stations in the Upper Potomac and Potomac Washington Metro basins located on the mainstem Potomac may not reflect the same conditions affecting MBSS stream sites within these basins. Remaining basins were ranked according to NO_3-N concentrations for each program. Ranks were then tested for correlation. This result was not significant ($p=0.31$), indicating that basin NO_3-N concentrations are ranked differently by the two monitoring programs.

There are several reasons for the differences in NO_3-N results between the two programs. The first is that the programs sampled at different locations within a basin. Therefore, differences in surrounding land use or even in natural water chemistry may be reflected in average NO_3-N concentrations. Differences in time of sample collections may also contribute to this variation. For instance, a sample for one program may have been taken after a rainstorm, when NO_3-N from runoff was present in higher concentration. Finally, the majority of CORE/Trend sites are located in fourth-order and larger streams, while the MBSS sites are restricted to third-order and smaller streams that may be more strongly influenced by direct watershed inputs. In larger streams, a similar rate of NO_3-N influx could be diluted by greater streamflow, resulting in lower instream concentrations. In fact, MBSS results showing slightly higher NO_3-N concentrations in first-order streams are consistent with this hypothesis. Furthermore, results of other surveys indicate that probability-based surveys such as the MBSS generally capture more disturbed sites than do fixed-site surveys. In future analysis, a more in-depth comparison could be done using specific MBSS sites located upstream of CORE/Trend stations, to examine geographic patterns in nutrient concentrations between small tributaries and corresponding downstream CORE/Trend streams, which integrate nutrient inputs over a larger watershed area.